



## Original Article

# Correlation between dental caries and diet, oral hygiene habits, and other indicators among elementary school students in Xiulin Township, Hualien County, Taiwan



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## ABSTRACT

**Objectives:** To analyze the correlations between oral health status and eating habits, oral hygiene habits, and other indicators by dental health examination and questionnaires. The target population was elementary school children in Xiulin Township, Hualien, Taiwan and the aim was the identification of the possible factors causing tooth decay.

**Materials and methods:** A stratified purposive sampling approach was used in this study. First and fourth grade students from 11 elementary schools in Xiulin Township were selected as participants in an oral health examination during the academic year 2012 and were also asked to fill in a questionnaire. Three hundred and nineteen students were initially involved in the study and the actual number of students who completed the questionnaire and the oral examination was 277; thus the survey response rate was 86.8%. Statistical analysis was used to evaluate the correlation between the student's oral health status and the responses in the questionnaire.

**Results:** The study participants from Xiulin Township have a high prevalence of dental caries as well as high indices for the following indices: decayed, extracted, and filled teeth in primary dentition (deft); decayed, missing, and filled teeth in permanent dentition (DMFT); and decayed, extracted, and filled teeth in primary dentition and decayed, missing, and filled teeth in permanent dentition (deft + DMFT). These high indices may be related to the fact that most of these children like to eat sweets and snacks, have poor oral hygiene habits, and have extremely low rates of using dental health care products. Mouth-cleaning after eating sweets, brushing after eating, and brushing for at least 3 minutes each time is able to effectively predict the deft + DMFT index of school children in Xiulin Township ( $R^2 = 0.218$ ,  $p < 0.0001$ ).

**Conclusion:** These findings provide information for the relevant health authorities in Taiwan with respect to ensuring an adequate distribution of dental care resources in mountainous townships and remote areas. The findings also indicate that there is a need for improved access to dental health care in these areas in the form of the presence of professional dental hygienists at every school to educate and supervise the school children to develop good oral hygiene habits.

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## 1. Introduction

Dental caries is a major oral health problem among children. According to the World Health Organization, about 60–90% of

school children worldwide have dental caries. The global target specified in 2000 was to ensure that 50% of children worldwide aged 5–6 years would be caries-free and that the average decayed, missing, and filled teeth in permanent dentition (DMFT) index would be reduced to  $< 3.0$  at 12 years of age. By 2011, the global average DMFT index for school children at 12 years of age was 1.67 and 78% of countries have a DMFT index  $< 3.0$ . In Asia, the DMFT index for children at the age of 12 years in Singapore in 2011 was the lowest at 0.6, followed by Japan with a score of 1.4. With the exception of Cambodia's score of 3.5 and the Philippines' score of

Conflicts of interest: none.

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3.3 in 2011, the DMFT indices for the various Asian countries for children at the age of 12 years are all < 3.0 [1]. However, the prevalence of dental caries among children aged 5–6 years in Taiwan was 79.32% in 2011. Furthermore, the DMFT index for children aged 12 years in Taiwan was 3.31 in 2000. Although the index had improved to 2.58 in 2006 [2], it remains above the global average, which indicates that there is still a need for further improvements in the dental health of children in Taiwan.

Oral health care resources in many remote areas of Taiwan are limited, which consequently leads to more serious oral health problems. According to a 2007 survey conducted by Yu et al [3], the decayed, extracted, and filled teeth in primary dentition and decayed, missing and filled teeth in permanent dentition (deft + DMFT) index for elementary school students aged 6–12 years in eastern Taiwan was 4.08 and the prevalence of dental caries was 51.92%. This number is higher than in all other regions in Taiwan over the same period, indicating that tooth decay remains a serious problem among children in Taiwan's eastern region. Another study published in 2001 by Yu [4] reported the use of dental care by aboriginal and non-aboriginal elementary school children in the Hualien–Taitung region, Taiwan; this report suggested that the distribution of dental care resources is significantly different between metropolitan and rural areas and that the available medical resources in mountainous areas are extremely restricted. Moreover, it was also found that aboriginal children have more serious tooth decay problems than Han children (3.15 teeth vs. 2.87 teeth) and that they also have a lower average number of fillings (0.66 teeth vs. 1.81 teeth). This supports the hypothesis that, although aboriginal children have a higher rate of dental caries, they also have a lower rate of fillings [4].

The Health Promotion Administration [5] conducted an oral health survey of children and adolescents in Taiwan in 2005 and the results from Hualien County showed no significant difference when compared with other counties (a deft index of 2.40, a dental caries rate of 39.91%, and a filling rate of 52.02%). However, a detailed examination of the participants of that survey indicates that both the elementary schools sampled (Stella Maris and Ming Yih primary schools) are located in Hualien City; in these schools, most students are not aboriginal and their socioeconomic situation is very different from that of families living in the mountainous areas of the eastern region of Taiwan. Thus these findings probably do not accurately represent the current status of aboriginal-based school children living in mountainous areas. Chen [6] screened aboriginal school children living in Xiulin Township in 2010 and found that the prevalence of dental caries among these children was 61.54% and the filling rate was 62.14%. However, this survey used a single community and the sample size was very small ( $n = 26$ ). The survey by Haung et al [7] in 2001 on preschool children in Xiulin Township also showed that the rate of dental caries among children < 6 years of age was higher than in the townships in low-lying areas and, furthermore, the rate of completing follow-up treatment was also lower. Specifically, the prevalence rate of dental caries was 89.24%, the filling rate was 3.20%, and the deft index was 7.58 [7]. At present, no complete set of data is available that allows a reliable analysis of the oral health status of aboriginal children at elementary schools in Taiwan's mountainous townships.

Xiulin Township has the largest area of the mountainous townships in Taiwan and most of the residents who live in this township are aboriginal people. Hualien Tzu Chi Hospital has been assigned to carry out the Xiulin Township Integrated Delivery System Program since 2004. In addition to regular outpatient clinics, Tzu Chi Hospital also actively participates in various other health-related activities. During the process of clinic visits under the Integrated Delivery System, dental caries is often found in local students. Many factors may lead to caries, such as eating habits, oral

hygiene habits, parents' educational level, socioeconomic status, and health care habits. Based on the results of a study conducted by Yu et al [3] in 2007, which used oral examinations of elementary school students aged 6–12 years in eastern Taiwan, the frequent consumption of sugary drinks and sweets, together with a lack of regular meals, is likely to be the cause of the increase in dental caries. In terms of the frequency of teeth-brushing, children who brush once a day have a higher number of decayed teeth as well as a worse index of dental caries than those who brush three or more times a day [3]. Moreover, children usually start to engage in these oral hygiene behaviors during the critical period when they attend elementary school. If they fail to develop good and correct teeth-cleaning behavior, their overall oral health will be affected.

This study focused on 11 elementary schools in nine villages within Xiulin Township and explores the correlation between oral health status and eating habits, oral hygiene habits, caregivers' assistance in oral hygiene habits, and the use of dental health care via a questionnaire and an oral examination of school children. The aim was to investigate the possible factors causing tooth decay.

## 2. Materials and methods

### 2.1. Research participants

Xiulin Township in Hualien County has a total of 12 elementary schools. Among these, the Sibao elementary school is located in a mountainous area and is classified as a rural elementary school in a free school district. Apart from the school's local students who live nearby, the majority of students at the school come from low-lying areas or other surrounding counties or cities and the school uses a dormitory system that requires all students to live on campus. As a result of these factors, the student composition and lifestyles are markedly different from other elementary schools in Xiulin Township and therefore this elementary school was excluded from our study. A stratified purposive sampling approach was used in this study and first and fourth grade students from the remaining 11 elementary schools in Xiulin Township were selected as study participants during the 2012 academic year. These children were given an oral health examination and asked to fill in a questionnaire. In total, 319 children initially took part in this study. The research team explained the contents of the study using a written description to the legal representatives of the research participants. They agreed their children could join the research and then signed an informed consent form. The research team then outlined the study's content to the research participants themselves during a public school activity and those who agreed were enrolled in this study. On completion, the survey response rate was 86.8% and consisted of 277 students in total.

### 2.2. Dental check-ups

An oral health examination of all the participants was conducted by a single dentist who had sufficient clinical experience for this purpose. The design of the oral health examination form is derived from the diagnostic methods and standards for the oral health examination survey released by the World Health Organization and it was appropriately modified according to the dentist's clinical experience. The number and conditions of the deciduous and permanent teeth of the children were recorded. Where decayed (dt, DT) is used, this represents a carious deciduous (permanent) tooth without fillings or the occurrence of secondary caries after failure of a filling. Where extraction (et) is used, this indicates the removal of a deciduous tooth due to severe caries. Where missing (MT) is used, this represents a permanent tooth missing as a result of caries. Finally, where filled (ft, FT) is used, this indicates a deciduous

(permanent) tooth that is filled due to caries using permanent or temporary materials. The calculation of the deft index uses  $(dt + et + ft)/\text{number of participants}$ , while the calculation of the DMFT index uses  $(DT + MT + FT)/\text{number of participants}$ .

### 2.3. Questionnaire format and content

The questionnaires were completed by the students under the guidance of school teachers and the content includes the following information: (1) demographic information on the student, their parents or their primary caregiver, including the sex and age of the student, as well as the education level and occupation of their parents or primary caregiver; (2) the diet habits of the school children, such as sweet-eating habits, snacking habits, the number of times they eat sweets or snacks each day, and mouth-cleaning habits after eating sweets; (3) the oral hygiene habits of the school children, such as frequency of brushing, duration of brushing, oral hygiene techniques, and oral hygiene habits; and (4) the student's perception of dental caries, the student's dental health care experience, and the student's oral health knowledge, such as knowledge of the main cause of dental caries and the main methods of preventing dental caries.

### 2.4. Statistical analysis

Statistical analysis was used to produce a frequency distribution table, percentages, averages, and standard deviations for the data collected. In addition, *t* tests and analysis of variance (ANOVA) were applied to analyze, compare, and evaluate the oral health status of the different sexes, the first grade school children, and the fourth grade school children. These results were further used to analyze the oral hygiene habits and eating habits of the school children in addition to recording their prior experience of visits to the dentist. Subsequently, the correlation between these factors was explored to identify possible causes of oral disease. Multiple regression analysis was performed to identify the factors that are able to predict the dental caries experience in mixed dentition. The students' age, sex, diet, oral hygiene habits, and dental health care experience were used as independent variables and the deft + DMFT index was used as the dependent variable. The statistical analysis was carried out using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA) for Windows.

## 3. Results

### 3.1. Distribution of the number of participants

In this study, all first and fourth grade students at 11 elementary schools in Xiulin Township, except for Sibao elementary school, were included as participants. The actual number of students who

completed the questionnaires and oral examination was 277 (Table 1), among whom 157 (56.7%) students were boys and 120 (43.3%) students were girls. Furthermore, 125 (45.1%) children were in the first grade and 152 (54.9%) children were in the fourth grade.

Table 1 gives the dental caries status of the school children's primary dentition as determined by oral examination. The prevalence of dental caries in the primary dentition of the boys and girls was 87.9% and 78.3%, respectively, and shows a statistically significant difference ( $p = 0.038$ ). Table 2 gives the dental caries status in the permanent dentition and Table 3 gives the status of mixed dentition caries. The dental caries rate and dental caries experience across the permanent and mixed dentition showed no statistically significant difference between boys and girls. In terms of grade level, regardless of the number of dental caries in the primary, permanent, or mixed dentition, the number of dental caries, the prevalence of dental caries, and the deft/DMFT/deft + DMFT indices showed a significant difference between the first grade and fourth grade students ( $p < 0.05$ ). Likewise, the filling rate for deciduous teeth and mixed dentition, but not for permanent dentition, also showed a significant difference ( $p < 0.05$ ) between the first and fourth grade students. It is worth noting that, among first and fourth grade students, the filling rate in the primary teeth was less than half (23.7% and 44.0%, respectively), while the filling rate in the permanent teeth was more than half (59.0% and 71.0%, respectively).

### 3.2. Frequency of eating sweets, snacking habits, oral hygiene habits, and dental health care habits

Table 4 gives the frequencies of eating sweets, snacking, oral hygiene habits, and dental health care habits of the school children in Xiulin Township. The results reveal that most children [151 (54.5%) participants] occasionally consume snacks or sweets and only 16 (5.8%) students indicated that they never eat snacks or sweets; the latter is the lowest proportion among all groups. In terms of frequency of mouth-cleaning after eating sweets, 53 (19.1%) students did not clean their mouths at all. A total of 127 (45.8%) students brushed their teeth every day, whereas 20 (7.2%) students did not brush their teeth daily. As for the category of brushing teeth after eating, the majority of the students [163 (58.8%)] sometimes brushed their teeth after eating and sometimes did not. Only 72 (26%) students brushed their teeth every time after eating. Nearly 50.9% of the children (141 students) brushed their teeth before going to bed, while less than half of the children [130 (46.9%)] brushed for more than 3 minutes. There were 134 (48.4%) students who often used the Bass method of brushing. Most students only went to a dentist when they had a dental problem [141 (50.9%)] and 21 (7.6%) students had never visited a dentist.

Table 5 shows that there is a statistically significance difference between brushing after eating and the  $dt + DT$ ,  $ft + FT$ ,  $deft + DMFT$

**Table 1**  
Sex- and age-weighted dental caries status of primary dentition among 277 school children in Xiulin Township.

Variable	n (%)	dt	et	ft	deft index	Filling rate (%)	Prevalence of caries (%)
Sex							
Male	157 (56.7)	4.57 ± 3.95	0.18 ± 0.99	1.90 ± 1.97	6.55 ± 4.07	34.1 ± 32.5	87.9
Female	120 (43.3)	4.45 ± 4.29	0.16 ± 0.59	1.65 ± 1.80	6.26 ± 4.56	33.9 ± 32.5	78.3
<i>p</i>		0.804	0.845	0.27	0.578	0.962	0.038
School grade							
First grade	125 (45.1)	7.45 ± 3.93	0.30 ± 1.18	1.98 ± 2.02	9.58 ± 3.59	23.7 ± 25.3	97.6
Fourth grade	152 (54.9)	2.11 ± 2.24	0.07 ± 0.36	1.64 ± 1.79	3.82 ± 2.80	44.0 ± 35.5	72.4
<i>p</i> <sup>a</sup>		<0.001	0.037	0.149	<0.001	<0.001	<0.001

Data are presented as mean ± SD values.

dt = decayed teeth; et = extracted teeth; ft = filled teeth.

<sup>a</sup> *p* calculated using the two-sample *t* test.

**Table 2**  
Sex- and grade-weighted dental caries status of the permanent dentition among 277 school children in Xiulin Township.

Variable	n (%)	DT	MT	FT	DMFT index	Filling rate (%)	Prevalence of caries (%)
Sex							
Male	157 (56.7)	0.71 ± 1.36	0.01 ± 0.16	1.41 ± 1.70	2.08 ± 1.98	65.0 ± 39.2	36.3
Female	120 (43.3)	0.71 ± 1.50	0.03 ± 0.20	1.49 ± 1.67	2.23 ± 2.41	71.0 ± 36.3	31.7
<i>p</i>		0.977	0.575	0.704	0.574	0.290	0.422
Grade							
First grade	125 (45.1)	0.35 ± 1.17	0.02 ± 0.18	0.39 ± 0.77	0.68 ± 1.12	59.0 ± 45.2	17.6
Fourth grade	152 (54.9)	1.01 ± 1.54	0.02 ± 0.18	2.32 ± 1.74	3.34 ± 2.10	71.0 ± 35.1	48.0
<i>p</i> <sup>a</sup>		<0.001	0.864	<0.001	<0.001	0.114	<0.001

Data are presented as mean ± SD values.

DT = decayed teeth; MT = missing teeth; FT = filled teeth.

<sup>a</sup> *p* calculated using the two-sample *t* test.

**Table 3**  
Sex- and grade-weighted dental caries status of the mixed dentition among 277 school children in Xiulin Township.

Variable	n (%)	dt + DT	et + MT	ft + FT	deft + DMFT index	Filling rate (%)	Prevalence of caries (%)
Sex							
Male	157 (56.7)	5.29 ± 4.13	0.19 ± 1.00	3.31 ± 2.51	8.62 ± 3.60	42.9 ± 32.0	92.4
Female	120 (43.3)	5.16 ± 4.39	0.18 ± 0.62	3.14 ± 2.30	8.48 ± 4.27	45.7 ± 33.0	85.0
<i>p</i>		0.803	0.941	0.547	0.766	0.48	0.061
Grade							
First grade	125 (45.1)	7.80 ± 4.13	0.31 ± 1.19	2.37 ± 2.15	10.26 ± 3.80	25.7 ± 24.8	97.6
Fourth grade	152 (54.9)	3.12 ± 2.98	0.09 ± 0.40	3.96 ± 2.39	7.16 ± 3.40	59.4 ± 29.9	82.2
<i>p</i> <sup>a</sup>		<0.001	0.043	<0.001	<0.001	<0.001	<0.001
Average of first and the fourth grades							89.2

Data are presented as mean ± SD values.

dt = decayed teeth; DT = decayed teeth; et = extracted teeth; MT = missing teeth; ft = filled teeth; FT = filled teeth.

<sup>a</sup> *p* calculated using the two-sample *t* test.

indices, the filling rate, and the prevalence of dental caries in mixed dentition ( $p = 0.022$ ,  $p = 0.006$ ,  $p = 0.025$ ,  $p = 0.003$ , and  $p = 0.009$ , respectively). In the case of the dt + DT and def + DMFT indices, those students who did not brush their teeth after eating had the

**Table 4**  
Snacking habits, consumption of sweets, oral hygiene habits, and dental health care habits of elementary 277 school children in Xiulin Township.

Variable	n (%)
Number of times a day that snacks and/or sweets are eaten	
Never	16 (5.8)
Occasionally	151 (54.5)
Once or twice a day	61 (22.0)
> 3 times a day	49 (17.7)
I clean the mouth after eating sweets	
No	53 (19.1)
Sometimes yes, sometimes no	77 (27.8)
Yes, I always brush my teeth after eating sweets	72 (26.0)
Yes, I always rinse my mouth after eating sweets	75 (27.1)
I brush my teeth every day	
No	20 (7.2)
Sometimes yes, sometimes no	130 (46.9)
Every day	127 (45.8)
I brush my teeth after eating	
No	42 (15.2)
Sometimes yes, sometimes no	163 (58.8)
Every time	72 (26.0)
I brush my teeth before going to bed	
Yes	141 (50.9)
No	136 (49.1)
I brush my teeth for at least 3 minutes	
Yes	130 (46.9)
No	147 (53.1)
The Bass method is the brushing technique often used	
Yes	134 (48.4)
No	143 (51.6)
Dental care habits	
Periodical check-up	53 (19.1)
Occasional check-up	62 (22.4)
Visit a dentist only when having dental problems	141 (50.9)
Never go to a dentist	21 (7.6)

highest scores and those who brushed their teeth every time had the lowest scores. Similar results were found for the prevalence of dental caries, with the highest rate of 97.6% being for those who did not brush their teeth, while that for students who brushed every time after eating was lowest (86.1%). Moreover, a statistically significance difference was also found between the category of usually brushing for > 3 minutes and the dt + DT score, the def + DMFT index, the filling rate, and the prevalence of dental caries ( $p = 0.003$ ,  $p = 0.001$ ,  $p = 0.021$ , and  $p = 0.003$ , respectively). The dt + DT and def + DMFT indices, as well as the prevalence of dental caries, among those who brushed for < 3 minutes were all higher than those who brushed their teeth for > 3 minutes, while the latter were found to have a higher filling rate than the former. Similarly, in the category of frequent use of the Bass method for brushing teeth, a significant difference was also found when this was compared with the dt + DT score, def + DMFT index, filling rate, and the prevalence of dental caries ( $p = 0.001$ ,  $p = 0.005$ ,  $p < 0.001$ , and  $p < 0.001$ , respectively). Moreover, the dt + DT score, the def + DMFT index, and the prevalence of dental caries of the students who usually used the Bass method to brush their teeth was lower than those who did not follow this technique, while the filling rate of the former was higher. In summary, children with poor oral hygiene habits have poor oral health. Although the analyses of health care habits and oral health status of school children did not show significant differences, the prevalence of dental caries among children who have never seen a dentist and among children who only see a dentist when they have dental problems (95.2% and 90.1%, respectively) is higher than among those who have regular or occasional check-ups (88.7% and 85.5%, respectively).

### 3.3. Multiple regression analysis

One aim of this study was to examine whether a student's sex, age, the primary caregiver's occupation, the primary caregiver's education level, number of siblings, birth order, eating of sweets

**Table 5**

Correlation between dental caries status for mixed dentition and oral hygiene/dental health care habits among 277 school children in Xiulin Township.

Variable	n (%)	dt + DT	et + MT	ft + FT	deft + DMFT index	Filling rate (%)	Caries prevalence (%)
I brush my teeth after eating (1)							
Sometimes yes, sometimes no (2)	42 (15.2)	6.83 ± 4.46	0.12 ± 0.45	2.29 ± 2.16	9.23 ± 4.19	28.4 ± 29.8	97.6
Every time (3)	163 (58.8)	5.07 ± 4.19	0.20 ± 0.66	3.57 ± 2.57	8.85 ± 3.91	47.2 ± 32.2	88.3
<i>p</i>	72 (26.0)	4.65 ± 4.04	0.19 ± 1.32	3.04 ± 2.03	7.51 ± 3.53	46.1 ± 32.1	86.1
Post hoc tests		0.022	0.852	0.006	0.025	0.003	0.009
		1 > 2/3		2 > 1	1/2 > 3	2/3 > 1	1 > 2/3
I usually brush my teeth for at least 3 minutes							
Yes	130 (46.9)	4.42 ± 4.07	0.17 ± 1.03	3.34 ± 2.37	7.73 ± 3.88	48.9 ± 33.3	83.1
No	147 (53.1)	5.94 ± 4.27	0.20 ± 0.67	3.14 ± 2.46	9.30 ± 3.78	39.9 ± 31.0	94.6
<i>p</i>		0.003	0.736	0.501	0.001	0.021	0.003
Bass method is the brushing technique often used							
Yes	134 (48.4)	4.35 ± 4.17	0.19 ± 1.01	3.53 ± 2.42	7.88 ± 4.03	52.2 ± 33.0	81.3
No	143 (51.6)	6.05 ± 4.15	0.18 ± 0.68	2.97 ± 2.39	9.20 ± 3.67	36.6 ± 30.0	96.5
<i>p</i>		0.001	0.906	0.055	0.005	<0.001	<0.001
Dental health care habits							
Periodical check-up	53 (19.1)	5.01 ± 4.54	0.09 ± 0.35	3.17 ± 2.30	8.58 ± 4.74	47.2 ± 29.9	88.7
Occasional check-up	62 (22.4)	4.47 ± 4.08	0.16 ± 0.63	3.66 ± 2.39	8.29 ± 3.70	51.3 ± 34.1	85.5
Only visit a dentist when having a dental problem	141 (50.9)	5.67 ± 4.29	0.26 ± 1.09	3.06 ± 2.48	8.79 ± 3.76	40.8 ± 32.7	90.1
Never go to a dentist	21 (7.6)	5.10 ± 3.39	0	2.67 ± 2.24	7.76 ± 3.06	36.3 ± 28.2	95.2
<i>p</i> <sup>a</sup>		0.302	0.43	0.225	0.642	0.105	0.618

Data are presented as mean ± SD values.

dt = decayed teeth; DT = decayed teeth; et = extracted teeth; MT = missing teeth; ft = filled teeth; FT = filled teeth.

<sup>a</sup> *p* calculated using two-sample *t* test and one-way ANOVA, followed by analysis.

eating, snacking habits, oral hygiene habits, and dental health care habits are able to predict the deft + DMFT index for mixed dentition; multiple regression analysis was selected to help answer these questions. Based on this model, students' age, the habit of cleaning the mouth after eating sweets, brushing after every meal, and brushing for > 3 minutes were all able to effectively predict the deft + DMFT index of the mixed dentition (Table 6). By way of contrast, sex, the primary caregiver's occupation, the primary caregiver's education level, number of siblings, birth order, and dental health care habits were not able to effectively predict the dental caries experience in mixed dentition. The coefficient of determination ( $r^2$ ) of the model is 21.8%, indicating that the four variables can explain 21.8% of the deft + DMFT index variance when examining mixed dentition.

#### 4. Discussion

The statistical analyses presented in the study indicate that the prevalence of dental caries in the first and fourth grade school children at 11 elementary schools in Xiulin Township was 89.2% (Table 3), which is much higher than the national prevalence of dental caries (51.1%) and the rate of Hualien County (75.1%) for first and fourth grade school children as reported by the Ministry of Education [8] for the academic year 2012. Moreover, according to the National Survey of Oral Health [2] with respect to the status of children and adolescents conducted in 2006, the deft index for

primary dentition and the DMFT index for permanent dentition of children at age 7 years were 5.23 and 0.48, respectively, and the DMFT index for permanent dentition of children at age 10 years was 1.33. According to the findings obtained from the 11 elementary schools in Xiulin Township, the deft index for the primary dentition of first grade children was 9.58 and the DMFT index for permanent dentition was 0.68; by comparison, the permanent dentition DMFT index of fourth grade children was 3.34. Thus we have determined that the elementary school children in Xiulin Township have significantly higher scores than the national average deft score and DMFT index in both primary and permanent dentitions. In addition, from the results of this study, the average filling rate among first grade school children for primary and permanent teeth was 23.7% and 59.0%, respectively, and 44.0% and 71.0% among fourth grade school children, respectively. This should be compared with the filling rate (after weighting by population) of children of the same age in other counties and in cities nationwide [5], which are 58.35%, 55.28%, 58.27%, and 65.81%, respectively. Thus although the average filling rate in primary teeth among children in Xiulin Township is significantly lower, no significant difference was found for the permanent teeth. This indicates that children in Xiulin Township not only have a serious caries problem, but also lack medical treatment in this area. This is likely to be due to distributional differences in dental care resources between cities and rural areas. Specifically, most mountainous townships lack sufficient dental health care resources.

Chan et al [9] investigated the oral health status of school children in southern Taiwan in 2009 and found that for the deft + DMFT index for mixed dentition, girls had higher scores (3.63 ± 3.31) than boys (3.52 ± 3.35). In addition, they found that the prevalence of dental caries for girls (53.49%) was higher than that for boys (52.02%), and that boys had a higher filling rate (56.31 ± 39.70%) than girls (56.07 ± 38.52%); no significant difference was observed between sexes. Our study also shows that there is no significant sex difference in the caries status of mixed dentition. However, from the perspective of the DMFT index regarding permanent teeth, this study shows that girls (2.23 ± 2.41) have an overall higher score than boys (2.08 ± 1.98). Similar results were also found in the study of Chen [5], where the DMFT index of girls with respect to permanent dentition (2.99 ± 3.40) was significantly

**Table 6**Analysis of the important influencing factors affecting the dental caries experience in mixed dentition by multiple regression.<sup>a</sup>

Predictor variable	Regression coefficient	95% Confidence interval	<i>p</i>	Standardized coefficient
Cleaning the mouth after eating sweets	0.527	0.141, 0.913	0.008	0.146
Brushing the teeth after each meal	-0.735	-1.413, -0.057	0.034	-0.119
Usually brushing for at least 3 minutes	-1.210	-2.071, -0.350	0.006	-0.155
Age	-1.008	-1.284, -0.731	<0.001	-0.387

<sup>a</sup>  $R^2 = 0.218$ .

higher than that of boys ( $2.33 \pm 2.93$ ;  $p < 0.05$ ). In addition, the dental caries rate (36.9%) in permanent teeth for girls was also higher than for boys (34.32%). Yang et al [10] examined the DMFT index for permanent teeth and found that girls had a higher score of  $1.87 \pm 0.16$  than boys ( $1.31 \pm 0.12$ ;  $p < 0.05$ ) and that the prevalence of dental caries among girls for permanent dentition (60.1%) was also higher than for boys (48.0%;  $p < 0.05$ ). Chang and Yang [11] reported that DMFT index of permanent dentition for girls was significantly higher than that for boys ( $1.32 \pm 1.78$  vs.  $0.91 \pm 1.36$ ;  $p < 0.05$ ) and that the prevalence of dental caries for permanent teeth (51.56%) among girls was also higher than for boys (51.56%;  $p < 0.05$ ). All these results seem to reach the same similar conclusion and the underlying cause of this finding may be the fact that girls develop permanent teeth slightly earlier than boys and thus their teeth are exposed to a caries-prone oral environment for relatively longer.

In terms of age, significant differences ( $p < 0.05$ ) were found among both first and fourth grade students in the prevalence of dental caries and deft/DMFT/deft + DMFT indices for primary, permanent, and mixed dentition in this study. These findings are very similar to those outlined in previous studies [3,5,10]. It is suggested that because elementary school children are in a period of mixed dentition and will gradually lose their deciduous teeth and develop permanent teeth over time, this leads to a reduction in the dental caries status of fourth grade school children with mixed dentition compared with first grade children. In addition, the filling rate for the primary teeth of first and fourth grade students is less than half (23.7% and 44.0%, respectively), while the filling rate for permanent teeth are both more than half (59.0% and 71.0%, respectively). This indicates that most children pay less attention to the treatment of primary teeth caries. Moreover, the filling rate in both primary and mixed dentition of fourth grade children is higher than that of first grade children and this difference is statistically significance ( $p < 0.05$ ). It can thus be suggested that most caregivers neglected the dental health of preschool children. Periodic instruction in oral hygiene and a dental condition examination by local dentists at elementary schools seems to have improved the filling rate of fourth grade children. Therefore it is essential to strengthen the concept of oral hygiene and dental health care among caregivers by increasing periodic health educational activities.

Dental caries is mainly caused by the attachment of sugar to teeth after eating; this leads to the production of acid due to uninhibited bacterial growth and the decalcification of the tooth surface. A frequent intake of sugar-containing food or drinks often leads to dental caries. According to a survey conducted by Chen [5], the dt scores and deft + DMFT index of children who like to eat and/or drink sugar-containing foods or drinks are significantly higher than children who dislike eating sweets and/or do not drink sugary drinks. Similar results have been reported by Yu et al [3] in a study of school children from the eastern areas of Taiwan. Based on the results of this survey, only 16 (5.8%) of the children never eat sweets or snacks and only 72 (26.0%) children brushed their teeth after eating sweets. This indicates that children in Xiulin Township have a higher rate of eating sweets and/or snacking as well as a lower rate of tooth-brushing after eating sweets. Clearly this could be one of the causes leading to the high prevalence of dental caries in this area of Taiwan.

In terms of oral hygiene habits, based on the study of Harris et al [12], when there is an infection with *Streptococcus mutans*, children tend to develop caries easily. In these circumstances, good oral hygiene habits, such as brushing every day and reducing the intake of a cariogenic diet, are important factors that are able to reduce infection with *S. mutans*. Chang and Yang [11] reported that children who brush their teeth after meals have a significantly lower rate of dental caries and a reduced DMFT index for permanent teeth

compared with children who do not brush their teeth ( $p = 0.0002$ ,  $p = 0.0116$ ). This study supports this and shows that children who brush their teeth after meals, brush their teeth for at least 3 minutes, and/or often use the Bass method of brushing have a lower prevalence of decayed teeth, a lower deft + DMFT index, and a lower rate of dental caries; all of these differences were found to be significant ( $p < 0.05$ ) when compared with children who do not brush their teeth after meals, brush their teeth for < 3 minutes, and/or seldom use the Bass method of brushing. This result is consistent with a number of previous reports and supports the idea that good oral hygiene habits are able to reduce the risk of developing dental caries.

If we examine the dental health care utilization of school children, based on the results of the survey of Chen [5], the deft + DMFT index of children who had experienced a site visit to a dentist is significantly lower than those who have had no experience of visiting a dentist (2.72 vs. 4.01). Furthermore, Lin et al [13] examined the oral hygiene habits of elementary school children in Kaohsiung County and found that the rate of visiting a dentist varied significantly from area to area ( $p = 0.037$ ). It was found that the regular dental health care behavior of children from mountainous areas is lower than that of children from low-lying areas. Vargas et al [14] also reported similar findings that children residing in rural areas seem to have less access to and a lower utilization of dental care than children residing in urban areas. Our study shows that children in Xiulin Township have a lower regular dental check-up rate (19.1%) and most children only visit a dentist when they have dental problems. There were 133 (48.1%) children who did not receive regular dental examinations because their caregivers were not available. Although no significant difference was noted between dental health care behavior and the deft + DMFT index and the number of dental caries, the prevalence of dental caries in children who had never visited a dentist was higher than those who had periodic check-ups (95.2% vs. 88.7%). This suggests that the dental health care utilization of school children in Xiulin Township is low and this could possibly be correlated with the high rate of dental caries. Based on the study of Vargas et al [14], there are alternative ways of making the best use of dental resources in a rural area. These include portable dental clinics that can be installed in rural schools or dental clinics that are staffed by dentists and dental hygienists on a rotation basis. These methods could easily be implemented in the schools in Xiulin Township to increase the rate of utilization of dental health care.

Other factors that may affect children's oral health include sex, age, the primary caregiver's occupation, diet, oral hygiene habits, and health care habits [5,10,11,13]. The results obtained from the inferential statistical analysis in this study indicate that age, the action of mouth-cleaning after eating sweets, brushing after eating, and brushing for at least 3 minutes every time are able to effectively predict the deft + DMFT index of school children in Xiulin Township for mixed dentition. Furthermore, according to the study of Alm [15], the establishment of good oral hygiene habits early in life is highly correlated with good oral health in the teenage years. Therefore, to reduce the risk of dental caries among elementary school children, it is essential to induce the concept of oral hygiene care at an early stage and effectively supervise the oral cleaning habits of children.

## 5. Conclusion

These results indicate that children in Xiulin Township have a high prevalence of dental caries and high deft, DMFT, and deft + DMFT indices; these seem to be related to the fact that most children in this area like to eat sweets and snacks, have poor oral hygiene habits, and have an extremely low rates of dental health

care utilization. These results provide information for the relevant health authorities in Taiwan with the aim of facilitating the adequate distribution of dental care resources in mountainous townships and remote areas. Such changes will also improve access to dental health care as well as promoting the universal use of professional dental hygienists who are able to educate and supervise school children with the aim of creating good oral hygiene habits. These results can also serve as a reference for formulating recommendations to schools and to help schools produce educational materials related to oral hygiene. In addition, it is hoped that the relevant hospital will invest more staff resources in Xiulin Township to improve the general knowledge of proper oral health care habits among school children, as well as their parents and caregivers, by establishing good oral hygiene habits, increasing the adoption of a proper teeth-brushing technique and increasing access to dental health care.

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